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Conceptualizing and operationalizing human wellbeing for ecosystem assessment and management

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ABSTRACT

There is growing interest in assessing the effects of changing environmental conditions and management actions on human wellbeing. A challenge is to translate social science expertise regarding these relationships into terms usable by environmental scientists, policymakers, and managers. Here, we present a comprehensive, structured, and transparent conceptual framework of human wellbeing designed to guide the development of indicators and a complementary social science research agenda for ecosystem-based management. Our framework grew out of an effort to develop social indicators for an integrated ecosystem assessment (IEA) of the California Current large marine ecosystem. Drawing from scholarship in international development, anthropology, geography, and political science, we define human wellbeing as *a state of being with others and the environment, which arises when human needs are met, when individuals and communities can act meaningfully to pursue their goals, and when individuals and communities enjoy a satisfactory quality of life*. We propose four major social science-based constituents of wellbeing: connections, capabilities, conditions, and cross-cutting domains. The latter includes the domains of equity and justice, security, resilience, and sustainability, which may be assessed through cross-cutting analyses of other constituents. We outline a process for identifying policy-relevant attributes of wellbeing that can guide ecosystem assessments. To operationalize the framework, we provide a detailed table of attributes and a large database of available indicators, which may be used to develop measures suited to a variety of management needs and social goals. Finally, we discuss four guidelines for operationalizing human wellbeing measures in ecosystem assessments, including considerations for context, feasibility, indicators and research, and social difference. Developed for the U.S. west coast, the framework may be adapted for other regions, management needs, and scales with appropriate modifications.

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1. Introduction

The concept of *human wellbeing* is attracting increasing attention in environmental science, policy, and management, most recently at the global scale and in marine contexts (Adger et al., 2005; Cope et al., 2013; Díaz et al., 2015; Mace, 2014; McLeod et al., 2005; Millennium Ecosystem Assessment, 2005a). In part, this is due to the inclusion of people and human societies in definitions of "ecosystem" (Mace, 2014; McLeod et al., 2005), the rise of the paradigm of ecosystem services (Díaz et al., 2015; Millennium Ecosystem Assessment, 2005a), and a renewed appreciation for human wellbeing as a better measure of social progress than conventional economic measures such as gross domestic product (GDP) (Cobb and Rixford, 1998; Gough and McGregor, 2007; Stiglitz and Sen, 2009). Social scientists, in fields such as fisheries anthropology, social forestry, health, and international development have produced a rich literature on human wellbeing as it pertains to the environment at individual, community, and societal scales, using a range of approaches (Chan et al., 2012; Charnley et al., 2012, 2008; Coulthard, 2012; Donatuto et al., 2014; García-Quijano, 2015; Pollnac et al., 2006; Pollnac and Poggie, 2006; Satterfield et al., 2013; Stephanson and Mascia, 2014). The challenge is to translate these diverse insights from the social sciences into a cohesive framework for assessing human wellbeing that is specifically designed for the current demands of environmental science, policy, and management (Breslow, 2015; Castree et al., 2014; Fish 2011; Hicks et al., 2016; Levin et al., 2014; Samhouri et al., 2014; Satterfield et al., 2013).

Ecosystem-based management (EBM) represents a shift from a single-species, extraction-oriented focus in resource management toward a more holistic philosophy that strives to balance the multiple interrelated dimensions of ecological integrity and human wellbeing (McLeod and Leslie, 2012; Millennium Ecosystem Assessment, 2005a). Integrated Ecosystem Assessments (IEAs) were formalized as an approach for implementing EBM in marine ecosystems (Levin et al., 2009), and seek to answer three primary questions: 1) What constitutes a "heathy" ecosystem?; 2) Is the ecosystem being assessed currently healthy?; and, 3) What management strategies can maintain or improve ecosystem health? IEAs use indicators to help answer these questions. Indicators represent features of the social or biophysical system that can be easily measured and tracked over time in order to understand how the system is changing, what interventions may be necessary, and whether these interventions are effective (Mascia et al., 2014). To date, IEAs have largely employed biophysical indicators to assess ecological conditions (Samhouri et al., 2014). However, because IEAs promise to consider the full social-ecological system (Levin et al., in press), they must explicitly include human wellbeing in the assessment, and thus must confront the challenge of operationalizing the concept of human wellbeing.

Human wellbeing evokes, variably, quality of life, happiness, and the social and economic conditions of individuals, communities and societies. Here we define human wellbeing as *a state of being with others and the environment, which arises when human needs are met, when individuals and communities can act meaningfully to pursue their goals, and when individuals and communities enjoy a satisfactory quality of life.* We build on the definition developed by the Wellbeing in Developing Countries research group (WeD) (Coulthard et al., 2011; McGregor, 2008), and, like others have done (Armitage et al. 2012), adapt it for EBM by emphasizing a dynamic set of conditions whereby the major dimensions of wellbeing operate at multiple social scales within a social-ecological context.

Global assessments of human wellbeing use comparable, objective, quantitative indicators to measure tangible qualities of the economy, the environment, human health, and education (United Nations, 2008; United Nations, Department of Economic and Social Affairs, 2007; United Nations Human Development Programme, 2014). These global efforts leave less tangible, yet important dimensions of wellbeing unassessed, such as social relationships, and cultural and spiritual values (Satterfield et al., 2013; Turner et al., 2008). National and regional assessments use more diverse measures than these global assessments, yet human connections to the environment remain underrepresented (e.g. Michalos et al., 2011; OECD, 2013a; Office for National Statistics, 2015) or limited due to lack of indicators and data (Australian Bureau of Statistics, 2013; see also the review by Smith et al., 2013). In cases where measures of wellbeing have been designed specifically for environmental management, they are typically assessed at scales and resolutions that are too coarse to definitively track the social effects of acute environmental events, such as an oil spill, or specific management actions, such as catch shares and boat buy-back programs (Dillard et al., 2013; Dunn, 2013; Leisher et al., 2013; Summers et al., 2014). Others are very specific, focused, for example, on fishing communities (e.g. Colburn and Jepson, 2012; Pollnac and Poggie, 2006), marine protected areas (Mascia et al., 2010) or forest ecosystems (Edwards, 2011), and therefore may not translate effectively to other social and ecological contexts. Additionally, ecosystem services frameworks (e.g. Millennium Ecosystem Assessment, 2005a) primarily attend to the one-way delivery of benefits from the natural environment to humans, without fully accounting for the interdependencies between social and ecological systems, and how management might directly affect wellbeing (Breslow, 2015; Fish, 2011; Satz et al., 2013).

Here we develop a comprehensive framework of human wellbeing as it relates to environmental conditions and management actions. Our effort was initiated by the U.S. National Oceanic and Atmospheric Administration (NOAA) to inform the IEA of the California Current, the large marine ecosystem that stretches from Vancouver Island, Canada, through the U.S. West Coast, to Baja California, Mexico (http://www.noaa.gov/iea/regions/california-current-region/index.html). We combine an analysis of U.S. marine and environmental management priorities with a synthesis of existing wellbeing concepts to advance a framework of human wellbeing that is expressly designed for EBM. Below, we propose four major constituents of wellbeing, outline a process for identifying policy-relevant attributes of wellbeing, and recommend guidelines for using the framework to select indicators and scope complementary social science research for ecosystem assessments. While our focus is on U.S. marine management, our approach is designed to be adaptable to other regions, management needs, and scales, with appropriate modifications.

2. A conceptual framework of human wellbeing

We developed a detailed conceptual framework of human wellbeing to guide the selection and analysis of social indicators for an IEA, and scope complementary social science research. In developing the framework, we strove to serve the needs of resource managers, while improving social science literacy and awareness of the multidimensionality of human wellbeing. Our framework is distinguished from several well-known examples in its very pragmatic emphasis on management needs. While other frameworks begin with theoretical principles (e.g. Meadows, 1998), empirical observations (Millennium Ecosystem Assessment, 2005b), or a review of existing domains and indicators (Smith et al., 2013), ours is built on an analysis of managers' responsibilities vis a vis human wellbeing as articulated in management and policy documents. These are then augmented and organized according to social science principles. In this way, the framework focuses attention on aspects of human wellbeing for which managers and decision-makers may be held accountable (Cobb and Rixford, 1998; Sojka, 2014). The framework is furthermore designed to serve as a conceptually sound structure through which managers can meet

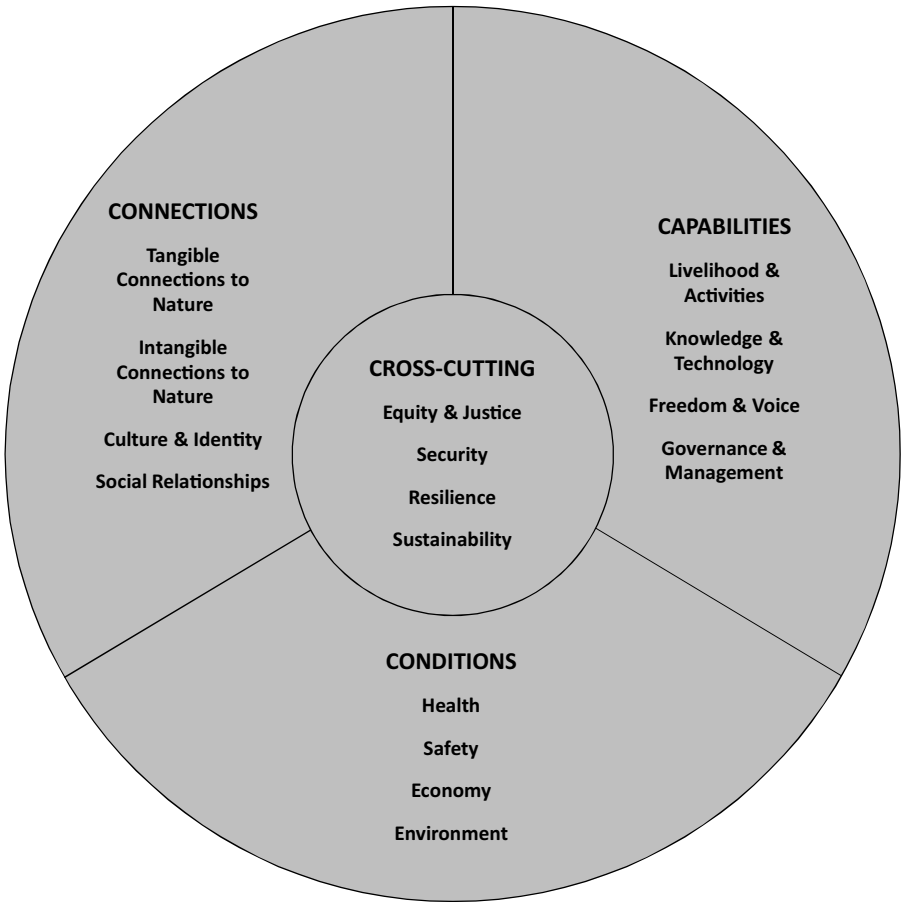

Fig. 1. The 4Cs conceptual framework of human wellbeing.
A framework of human wellbeing for ecosystem-based management that calls attention to four major constituents of human wellbeing: *connections, capabilities, conditions,* and *cross-cutting domains.* Each constituent is in turn associated with four major domains.

the increasingly common expectation to conduct ecosystem assessments using available indicators and existing data. At the same time, it serves to highlight where original social science research is needed to understand the complex, intangible, subjective, and currently understudied dimensions of human wellbeing. Finally, like many other approaches, we stress that the framework should be adapted to local goals and values using participatory processes. However, since public participation is not always democratic or equitable (Cobb and Rixford, 1998; Scott, 2012), we deliberately build in measures of freedom and voice, and equity and justice. Our framework encourages a pragmatic and conceptually robust approach to assessing human wellbeing, rather than one dictated by available indicators and data.

The resulting "4Cs" framework (Fig. 1) draws inspiration from several major, independent conversations regarding human wellbeing and the human dimensions of environmental challenges. It conceptually integrates insights from fields currently underrepresented in environmental science, such as anthropology, geography, and political science, with more commonly encountered approaches to wellbeing found in economics and international development (see Supplementary material Appendix A). The framework is structured according to a set of nested categories: constituents, domains, attributes, and indicators (Fig. 2).

We operationalize human wellbeing by decomposing it into four major constituents: *conditions, connections, capabilities*, and *cross-cutting domains* (hence "4Cs"). Each constituent is in turn composed of four recognizable domains with relevance to EBM. Note that each constituent also reflects a clause of our definition. *Conditions* refer to circumstances in which "human needs are met," and include the tangible qualities of environment, economy, safety, and human health, which are commonly measured in general wellbeing assessments. *Connections* refer to "being with others and the environment," and include the tangible and intangible interrelationships we have with other people and with nature, and our cultural values and identities. *Capabilities* are the factors

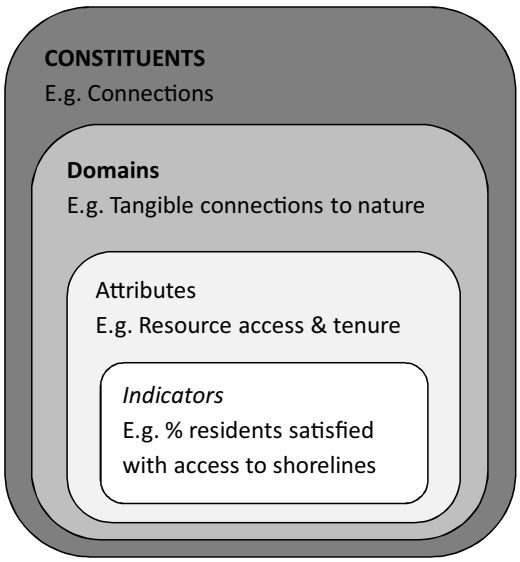

Fig. 2. The nested structure of the 4Cs framework of human wellbeing.

directly enabling individuals and communities to "act meaningfully to pursue their goals," including activities, knowledge systems, political participation, and governance. Finally, the *cross-cutting* domains of equity and justice, security, resilience, and sustainability suggest a state of caring for oneself, other people and living things, and sustaining our collective "satisfactory quality of life," now and into the future. These are inherent domains of wellbeing in that they impinge directly on one's wellbeing, and they are also "cross-cutting" because their status results from variabilities and interactions among all constituents.

The 4Cs framework calls central attention to the four cross-cutting domains. *Equity and justice* are central concerns in social sciences and studies of human wellbeing, yet their significance for EBM remains underappreciated (Hicks et al., 2016; Turner et al., 2008). Relative experiences and perceptions of inequity directly influence wellbeing: one's location in a social hierarchy contributes to one's negative or positive quality of life in a self-reinforcing pattern (Luttmer, 2004; Marmot et al., 1991; Morris and Halkitis, 2015; Wilkinson, 2010). Pragmatically, inequities in resource access and decision-making can lead to inter-group conflicts and retaliation that complicate management goals (Breslow, 2014a, 2014b; Goldman et al., 2013) Managers may also have a legal responsibility to identify and reduce inequities in exposure to environmental hazards, e.g. as mandated in the U.S. executive order on environmental justice (Executive Order 12898). Similarly, having confidence in the *security* of favorable conditions, such as employment or democratic governance, and in one's *resilience* or adaptability to changing conditions, such as climate change, contributes directly to one's wellbeing (Adger, 2006; Nelson et al., 2007; Smit and Wandel, 2006). More broadly, the wellbeing of human society over the long term depends on its ability to *sustain* all elements of human wellbeing while maintaining the quality of the environment on which it depends (Stiglitz et al., 2010).

2.1. Identifying and organizing attributes

Identifying relevant attributes for each domain of wellbeing is an instrumental step for developing indicators of status and change. Here, attributes were identified for their social science validity, and their relevance to the social, ecological and management context of the California Current region (Table 1). In addition to providing conceptual structure, Table 1 serves as an index to an underlying database of existing indicators (see Supplementary material Appendix B), and helps identify areas where new indicators may need to be developed. The table is designed to facilitate the selection of indicator portfolios for an IEA.

We used a systematic process to develop the 4Cs framework, aiming for both management relevance and conceptual validity. We first identified human wellbeing priorities articulated in U.S. governmental documents. We reviewed twelve major U.S. federal legislative, policy, science, and management documents guiding management of the U.S. west coast marine and coastal region (Table 2). We used qualitative analysis techniques and employed AtlasTi software to select and code keywords, phrases and paragraphs that described how the marine environment and marine management are thought to benefit people directly, or that reflected social goals for marine policy and management.

Using the same technique, we next identified attributes of wellbeing articulated in reports of the Commission on the Measurement of Economic Performance and Social Progress (also known as the Sarkozy Commission), a high profile initiative led by internationally-recognized social scientists to identify alternatives to gross domestic product (GDP) as a metric of human progress (Alkire, 2008; Stiglitz et al., 2010; Stiglitz and Sen, 2009).

We then compared the two lists of attributes. Many of the major areas of wellbeing expressed in these two sets of documents overlap, while others are unique to each source (Table 3). Those unique to the legislative and policy documents suggest areas of wellbeing that may be of specific interest to U.S. environmental decision-makers and managers. Areas unique to the Sarkozy Commission reports may suggest concepts of wellbeing developed in the social sciences that have not yet captured the attention of U.S. environmental managers. Together, they begin to construct a comprehensive typology of human wellbeing applicable to EBM in the California Current region.

We tested the operational utility of this preliminary list of attributes by using it to organize and code 2300 existing indicators (see Supplementary material Appendix B) sourced from 34 social-ecological indicator projects (see Supplementary material Appendix C). While the preliminary list proved to be relatively stable, this step led us to add or modify several attributes in order to accommodate the wide range of existing indicator topics. We further tested the ability of the list to capture human wellbeing priorities identified in several additional governmental documents (see Supplementary material Appendix D), including general U.S. and Canadian federal environmental legislation and the UN Declaration on the Rights of Indigenous People. In these ways, the list of attributes was tested and modified for applicability to regions beyond the U.S. west coast.

Finally, we organized these preliminary attributes into thematic clusters that became the domains of our conceptual framework. We then worked in an iterative fashion to modify the categories and wording of the domains and attributes to achieve a final list (Table 1) that reflected our shared expertise regarding human wellbeing, resonated with key subjects in the social science and management literatures, and could serve as an index to existing indicators.

3. Guidelines for operationalizing the framework

The 4Cs framework is designed to assist in selecting a conceptually valid and pragmatic set of social indicators for EBM, and in outlining where additional social science research is needed. To operationalize the 4Cs framework, and by way of discussion, we provide the following guidelines. (For detailed examples of guidelines 2 and 3, see Breslow et al., n.d. For best practices in social science research methods and data, see Charnley et al., in review).

1. Tailor the framework to the context of interest. Although designed for generalizability, the 4Cs framework was initiated for the U.S. west coast region, and will need to be modified for other contexts. To achieve local validity while maintaining conceptual validity, the goal is to revise domains, attributes, and indicators so they are meaningful to the intended audience, while still reflecting the major constituents of wellbeing. Large-scale and comparative assessments must take special care to ground-truth local validity before generalizing results across diverse social groups and geographies. Contextual relevance can be achieved through analysis of stated management goals and responsibilities for the region of interest, as illustrated above (see also Sojka, 2014), contextual research such as historical and ethnographic studies, and participatory processes that identify local social goals and concepts of wellbeing (e.g. see Biedenweg et al., 2014; Britton and Coulthard, 2013; Donatuto et al., 2014, 2011). The latter may entail public meetings with representative decision-makers and stakeholders, community meetings, focus groups, and in-depth interviews. Note that this is a major step still required for the California Current indicators. In addition to improving the final set of indicators, participatory processes can themselves improve human wellbeing by fostering social relationships and trust (Eldridge, 2013; Fraser et al., 2006; Levine and Feinholz, 2015; Scott, 2012).

Table 1
Major attributes of human wellbeing identified for their relevance to ecosystem-based management in the California Current region. The left-hand column lists constituents (dark grey), domains (grey), and attributes (light grey). The right-hand column lists working definitions of attributes (in bold), and examples of indicator topics related to each attribute (in italics). See Supplementary material Appendix B for existing indicators relating to each attribute.

Human Wellbeing Categories	Attribute Definitions *Indicator Topics*
CONNECTIONS	
Tangible Connections to Nature	
Resource Access & Tenure	Direct avenues & outcomes of access to natural resources *Evidence of access to natural resources (e.g. water, minerals, wildlife, fish); constraints to access; land and resource ownership; modes of access; natural resource harvests*
Access to Nature	Direct avenues & outcomes of access to nature and natural places *Recreational and tourism access; wildlife viewing areas; proximity to green spaces, water, and open space; recreation and tourism experiences*
Stewardship	Active conservation & sustainability practices *Protected areas; restoration; recycling; environmental education; organic farming; ecosystem health; green building*
Intangible Connections to Nature	
Beauty & Inspiration	Aesthetic value and creativity inspired by nature *Viewshed, aesthetic value, inspiration, waterfront*
Sense of Place	Meaning & identity connected to a place *Activities on the landscape, heritage, social and emotional connections to places*
Spirituality	Sense of spirituality or connectedness with environment
Culture & Identity	
Identity	Sense of self or community *Individual, household, and community symbolic sense of relationships; self-definition (individually and in relation to community); sense of connection to labor and environment*
Cultural Values & Practices	Culture, language, & the arts *Languages spoken; cultural sites; cultural practices; arts; traditional ecological knowledge; environmental ethos; community events*
Heritage	Generational connections to place & culture *Multi-generational interaction with natural resources; archeological and historic sites; cultural resources; acceptable historical change*
Social Relationships	
Family & Community	Personal relationships & community support *Family, joint family endeavors; sense of community, trust in neighbors, marriage & divorce, childcare, community spaces (e.g. play grounds and community halls)*
Civil Society	Non-governmental society *Private and non-profit organizations (e.g. religious, environmental, and social service groups); volunteering*
Social Diversity & Integrity	Social fabric & inter-community relations *Demographic characteristics (population, density, race/ethnicity, immigration and emigration, age and gender distributions); trust in people; inter-group relations; refugees; urbanization*
CAPABILITIES	
Livelihood & Activities	
Subsistence	Harvesting food & materials for self, family, or community *Subsistence harvests, access to resources and knowledge, ability to meet costs and obtain permits*
Job Quality	Job quality *Job duration, employment options, living wage, benefits & flexibility, job satisfaction*
Recreation & Tourism	Recreation and tourism assets, opportunities, & attendance

Table 1 (*Continued*)

Time for Fulfilling Activities	Amount of leisure time *Time spent working, commuting, volunteering, voting, recreating; work-life balance*
Knowledge & Technology	
Education & Information	Possession & transmission of knowledge, information & skills *Literacy rates; educational access, attendance and achievement; training; qualifications; access to information; advisories; outreach; specialized knowledge & skills*
Research & Technology	Production of new knowledge & tools *Support for and level of research and technology; patents; access to technology and data; ability to produce/contribute new knowledge*
Freedom & Voice	
Self-Determination	Independence, agency, freedom from social or governmental constraints *Autonomy and ability to control one's own life; financial independence and debt; access to credit*
Political Participation	Having a voice in decision-making *Voting; participation in decision-making processes and leadership; stakeholder processes; exercising rights; interest in politics*
Sovereignty	Self-governance & indigenous sovereignty *Local, regional or indigenous control; tribal treaty rights*
Governance & Management	
Resource Management	Governmental management of natural resources *Effectiveness of management; perceptions of management; permits & regulations; adequate funding and staff capacity for achieving management objectives; partners and collaboration; voice and participation in management*
Public Services	Governmental social services *Health & human services; public utilities & transit; public expenditures*
General Governance	Principles and practices of effective governance *Public debt, taxes, governmental expenditures; inter-agency coordination; transparency*
CONDITIONS	
Health	
Food	Food & water access, quality, & security *Agricultural and fisheries harvests; food & drinking water access, abundance, quality, security & sovereignty; nutrition; fertilizers & pesticides*
Physical Health	Health conditions, access to health care & healthy choices *Disease, injuries, life expectancy, birth and death rates, mortality; access to health care, healthy food & lifestyle; health advisories; perceptions of health*
Emotional & Mental Health	Mental health, emotional wellbeing, & perceived quality of life *Happiness, attitude, trust, subjective wellbeing, stress, depression, suicide rates*
Safety	
Disaster Preparedness	Preparedness for large-scale environmental disasters *Preparedness for oil spills, tsunamis, climate change, severe weather; density in hazard zones; communications infrastructure; number of events; life and value lost*
Physical Safety	Safety at work and at home *Occupational risks and emergency services, building codes, injuries*
Peace & Security	Presence, absence and prevention of violence and war *Crime, non-compliance, emergency services, sense of personal safety, acts of violence, refugees*
Economy	

Table 1 (*Continued*)

Local & Informal Economies	Exchange of goods and services locally and/or outside of money economy *Farmers' markets; local producers & consumers; gifting, bartering, trading; value, volumes and percentages of reciprocal and in-kind "transactions"*
Material Wealth & Security	Material assets & consumption *Resources consumed, possessions, costs & affordability, basic needs, poverty, debt, access to credit, material security*
Employment & Income	Employment and income levels *Jobs, wages, and income overall & by sector and social variables; sector diversity within a population; poverty (see "job quality" for other employment characteristics)*
Industry & Commerce	Commercial & industrial production, trade & revenue *GDP, investment, general economic activity, business & industry sector characteristics, commercial resource harvests and extraction*
Environment	
Infrastructure	The human built environment *Roads, ports, housing & transit; development configurations; recreational assets; impervious surface*
Pollution & Waste	Anthropogenic pollution & biotoxins *Municipal & hazardous waste, sanitation, recycling, air & water quality, carbon emissions, shellfish & beach closures, fish consumption advisories, surface filtration & run-off*
Environmental Quality	Quality or condition of natural environment & natural resources *Ecosystem health, integrity, productivity; land use intensity; soil & water quality; invasive species, habitat fragmentation & degradation; restored habitats*
Resource Abundance & Distribution	Quantity and coverage of natural resources and ecosystem types *Land cover, use & designations; species assemblages & abundances; protected areas, parks, & gardens*
CROSS-CUTTING	
Equity & Justice	*Comparisons for all attributes across gender, age, ethnicity, income & other social variables; evidence of racism & discrimination; rights; human rights violations*
Security	*Evidence of stability of favorable conditions among all other attributes, and ability to plan future in the short-term*
Resilience	*Evidence of social-ecological adaptability to changing conditions among all other attributes*
Sustainability	*Sustainability in the long-term for all other attributes and activities: long-term, multi-generational practices; fossil fuel production and consumption; depletion of non-renewable resources; species extinctions*

Table 2
U.S. legislative, policy, science and management documents pertaining to marine and coastal management of the California Current region analyzed for attributes of wellbeing.

Legislative documents
Magnuson Stevens Act Amended (2007)
National Marine Fisheries Service National Standards Guidelines (2009)

Policy documents
Executive Order: Stewardship of the Ocean, Our Coasts, and the Great Lakes (2010)
Ocean Policy Task Force Final Recommendations (2010)
Ocean Research Priorities Plan Update (2013)
National Ocean Policy Implementation Plan (2013)

Science and management documents
California Current Integrated Ecosystem Assessment Report Summary (2012)
California Current Integrated Ecosystem Assessment Human Dimensions Chapter (2013)
California Current Integrated Ecosystem Assessment Engagement Chapter (2013)
Pacific Fisheries Management Council Draft Indicators (2013)
Pacific Fisheries Management Council Pacific Coast Ecosystem Fishery Plan (2013)
Pacific Fisheries Management Council Pacific Coast Fishery Ecosystem Plan Ecosystem Initiatives Appendix (2013)

Table 3
Preliminary attributes of wellbeing resulting from an analysis of U.S. governmental documents (Table 2) and the Sarkozy Commission reports (Alkire, 2008; Stiglitz et al., 2010; Stiglitz and Sen, 2009). # = domains unique to the U.S. governmental documents; * = domains unique to the Sarkozy Commission reports.

	Agency/Self-Governance/Sovereignty		Infrastructure/Built Environment/Housing
#	Archaeological/Historic Heritage		Jobs/Livelihood/Employment
	Beauty/Aesthetics/Amenities		Local Economies/Corporate Consolidation
	Certainty/Predictability/Ability to Plan Future		Material Wellbeing/Wealth/Prosperity/Economic Security
*	Civil Society	*	Personal Activities/Time Allocation
	Commerce/Trade/Revenue		Place Attachment/Sense of Place/Place-Based
#	Community Vibrancy/Integrity/Stability/Adaptability		Public/Political/Democratic Participation
	Conflict Reduction/Resolution		Recreation and Tourism
	Cultural Values/Traditions/Valued Practices		Resilience/Hazards Preparedness
	Demographics – Diversity/Density	#	Resource Access, Availability, Utility
#	Diversity/Multiple Resource Users		Science/Research/Knowledge
	Education/Outreach/Awareness		Security/Peace/Safety
*	Emotion/Attitude		Social Capital
	Environmental Quality		Social Justice/Equity
#	Environmentalism/Stewardship/Conservation	*	Social Relationships
#	Food/Nutrition/Food Security	#	Subsistence
	Governance/Management/Public Services		Sustainability/Future Generations' Wellbeing
	Health (Physical and Mental)	#	Wonder/Spirituality/Existence Value
*	Identity		

2. Identify and conceptualize focal attributes. Indicators serve multiple purposes, from technical analyses to symbolic communication, and they require resources to develop and use. It may not be desirable, nor feasible, to develop indicators for all attributes in Table 1. This raises the question of how to select a small set of indicators that collectively reflect the complexity of human wellbeing. One solution is to work with managers and stakeholders to identify a subset of priority areas of wellbeing, here called *focal attributes*, with at least one drawn from each of the outer constituents of the framework (conditions, connections, and capabilities). If fully conceptualized, focal attributes can reflect the breadth of wellbeing while focusing indicators on priority areas. This is because, despite the analytic need for distinct categories, attributes of human wellbeing are not inherently mutually exclusive entities (Alkire, 2008). An in-depth conceptualization of each *focal attribute* will reveal that it overlaps with many of the other attributes in the conceptual model. For example, "resource access" depends on many factors, such as environmental and economic conditions, physical health, social relationships, and participation in resource management decisions (Breslow et al., n.d.). Thus, as a focal attribute, "resource access" can provide insight into each of these related attributes of wellbeing, with an emphasis on their significance with respect to accessing natural resources. In this way, carefully selecting a set of *focal attributes* can create a more manageable, yet still balanced framework through which to select indicators.

3. Develop a set of indicators for each focal attribute, and identify where complementary research is needed. Choosing indicators for a specific attribute typically involves compiling available candidate indicators, screening them according to predefined criteria, and selecting parsimonious sets that serve the purpose at hand (James et al., 2012; Kershner et al., 2011; Levin et al., 2009). To facilitate the selection process, we developed a database of nearly 2300 existing social indicators (see Supplementary material Appendix B) compiled from 34 projects around the world (see Supplementary material Appendix C) and coded each indicator with relevant attributes from Table 1. With this database, one can quickly identify a list of indicators pertaining to one or more attributes. If needed, additional indicators can be added to the database, and the coding scheme can be modified. Standard guidelines outline criteria for selecting valid and measurable indicators; specific criteria for IEA indicators are sensitivity and responsiveness to environmental or management change (Gregory, 2012; Keeney and Gregory, 2005). With these criteria, new indicators may need to be developed to fully assess human wellbeing in an EBM context (Breslow et al., n.d.).

After the screening process has identified a short list of candidate indicators, it is important to evaluate them for their coverage of desired qualities. For example, it may be desirable to measure indicators that provide insight into wellbeing at various levels of social organization (individual, community, societal); that track leading causes as well as lagging consequences of change; and that can provide general as well as specific insights into wellbeing. In particular, social indicators, unlike biophysical indicators, can be both *objective* and *subjective*, meaning they can measure both externally observable features of wellbeing, as well as how people perceive their own wellbeing—which is in itself an important dimension of wellbeing. For example, an objective measure of "resource access" might be miles of publicly accessible shoreline, while a subjective measure might be whether a respondent feels they have sufficient access to the shoreline. We suggest it is important to develop a mix of objective and subjective indicators for each focal attribute, to enable comparisons among objective circumstances, test how they relate to subjective experiences, and assess if and how both differ across social variables.

At this stage it is important to evaluate whether existing indicators and data can adequately assess focal attributes and overall human wellbeing in the region or community. A gap analysis can help identify where complementary qualitative or quantitative social science research may be needed, such as to assess the subjective and less tangible dimensions of wellbeing and the interrelationships among multiple dimensions of wellbeing.

4. Measure indicators and conduct cross-cutting analyses and contextual research. Both quantitative and qualitative data are valuable for measuring and assessing social indicators. Quantitative data presented in tables, charts, and maps can quickly communicate status and trends in human wellbeing. Qualitative information can provide essential detail regarding the contexts and causal relationships that explain if and how those trends are related to environmental and management changes. Qualitative data often provide more robust insight into certain domains of human wellbeing, such as culture and identity, and intangible connections to nature. However, sufficient data of either type may not be readily available, and new data collection will likely be necessary. Specifically, measuring subjective indicators will likely require surveys and interviews.

A crucial step is to analyze indicators across social variables and time in order to assess cross-cutting domains. While aggregated indices or average indicator values can be useful, measuring and comparing the wellbeing of different social groups is necessary in order to reveal inequities (Daw et al., 2011). Furthermore, measuring attributes over time – whether using historical data or periodic monitoring – enables assessment of the degree of security, change, and resilience to disruptive change that individuals and communities experience in multiple aspects of their lives. At the broadest scale, an assessment of social-ecological sustainability entails evaluating key variables, such as energy production and consumption, resource use and condition, and social equity, as to whether they can collectively persist in desired conditions over multiple generations (Stiglitz and Sen, 2009).

Finally, research into the historical and social context of the region and community is essential for accurately interpreting the significance of indicator results (Breslow, 2014b; Charnley et al. in review).

4. Conclusion

With increasing attention to the human dimensions of environmental problems, efforts are underway to assess the effects of changing environmental conditions on human wellbeing. Here, we present and operationalize a comprehensive framework to guide the selection of indicators and scope a complementary research agenda. The framework is designed to promote structured, transparent, and comprehensive indicator sets and research that can capture how the major constituents of wellbeing are affected by both environmental changes and management strategies. We offer this framework in the spirit of encouraging richer engagement with the social sciences in EBM, a deeper understanding of the human-environment relationship, and, ultimately, the meaningful improvement of human wellbeing as an integral part of planetary sustainability.

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Appendices A–D. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.envsci.2016.06.023.

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